USING LOCAL INFORMATION FOR COMPOSITING CG INTO TRADITIONAL ART

A Thesis

by

JONATHAN HORACE KIKER

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

May 2009

Major Subject: Vizualization Sciences

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Approved by:

Chair of Committee,	Ergun Akleman
Committee Members,	Richard Davison
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Head of Department,	Tim McLaughlin

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ABSTRACT

Using Local Information for
Compositing CG into Traditional Art. (May 2009)
Jonathan Horace Kiker, B.E.D., Texas A&M University
Chair of Advisory Committee: Dr. Ergun Akleman

I describe a procedure for compositing digital graphics into traditional artwork based on local characteristics of the art. This is based on understanding that variations in pictorial characteristics such as perspective, lighting and color, or style naturally occur in many examples of traditional artwork. The goal of this study is to create composites that are visually believable while showing that an object composited into one section of an image requires characteristics designed specifically for that section. In order to show this, I examine four different case studies. Each case is a work of traditional art which I composite different computer graphic elements into. These CG elements range from simple primitive objects to complex character models.

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CHAPTER I

INTRODUCTION

A. Motivation

In many digital animations and projects artists use matte or background paintings as a way of creating complex backgrounds that require far less rendering time than if the scene was entirely CG. These paintings usually come as a response to what has already been created digitally, and are designed to seamlessly blend in behind the digital elements. But imagine this process being reversed, and it is the CG elements that are created as a response to an existing painting? Traditional artwork has no real rules guiding it, and therefore information such as perspective, lighting, color, or texture can vary in different areas of the work. This creates an interesting challenge for compositing digital characters or objects into the original traditional art as they must not only match the global style of the art, but also make sense locally.

The journal model is *IEEE Transactions on Automatic Control.*

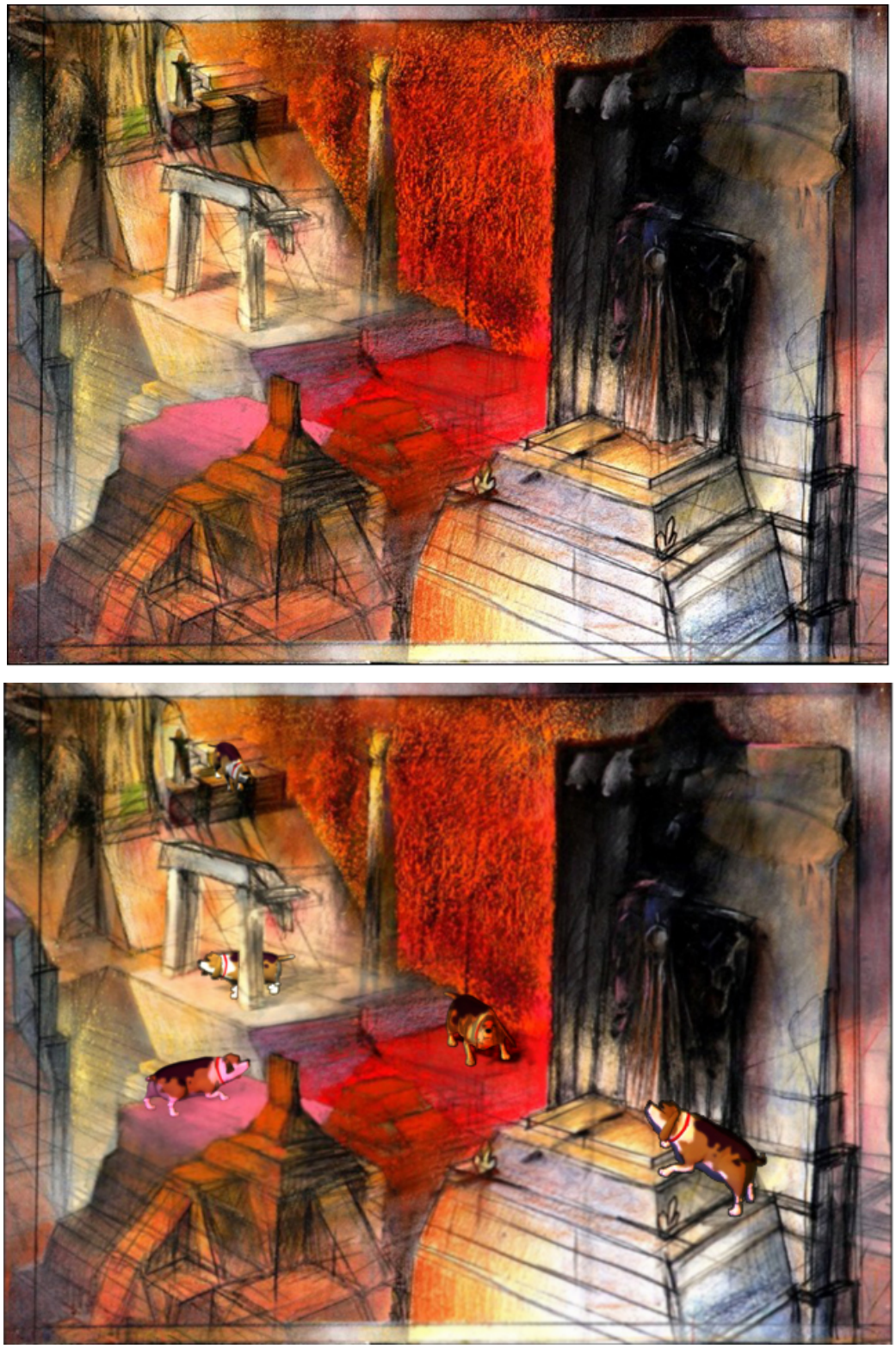

Fig. 1. Image comparison with and without CG elements.

B. Introduction to compositing

The basic goal of compositing is to create one final image from any number of layered images. This process typically starts with a background image, with foreground images subsequently composited on top. The classical example of this process is in cel-animation. Cel-animation starts with a background plate, and then various character plates and foreground object plates are stacked on top of each other as well as the background, then photographed to create a final image. This allows the animator to simply change one or two of the plates without having to redraw the entire scene for each frame of the animation.

In the movie industry compositing has many applications. For example, there may be a need for interaction between some sort of imaginary character, perhaps an alien monster, and live actors. Another example where compositing is often used in the movie industry is to place live actors in some sort of imaginary world. Instead of building a complex set, directors are able to create this set in a computer and composite their actors into the scene. In short, compositing gives directors the freedom to create images that would otherwise be impossible.

In every example of compositing, the ultimate goal is for the final image to be visually seamless. All objects, digital and real, foreground and background need to seem as if they exist in the same space. Basically, good compositing hides the fact that compositing has taken place.

C. Compositing with traditional art

To start the process of compositing CG into traditional art it is important to first understand the artwork and how it works as a composition. The piece in figure 2 is an example of one that has a great deal of variation in almost all of its aspects. When

working with such a piece, the object or objects composited into the work should share the same variations where necessary. When compositing a number of small objects throughout the art, each object must consider the elements that surround it locally. If it is one large object being composited across the entire piece, that object must take into consideration all visual variations it crosses. However, in both of these cases it is necessary for the object(s) to fit globally in the artwork. One common characteristic of many works of traditional art is that inconsistencies exist. These inconsistencies can include physical aspects such as texture or brush strokes, or technical aspects such as light direction or vanishing points.

Fig. 2. Example of a piece in which the information varies across it.

1. Three main characteristics that may vary

I will define the following three main characteristics as the most important in considering the process of compositing CG elements with traditional art. Although every characteristic is important, I will consider these as the primary categories.

- Perspective
- Lighting (color)
- Style (mark making and details)

2. Types of perspective variation

The first type of perspective variation I define as "flowing perspective". In this case there is never really a single defined vanishing point. This can be seen in works such as M.C. Escher's "Print Gallery", or the example in figure 3. Although the perspective seems to flow along a predictable path, nothing should be assumed.

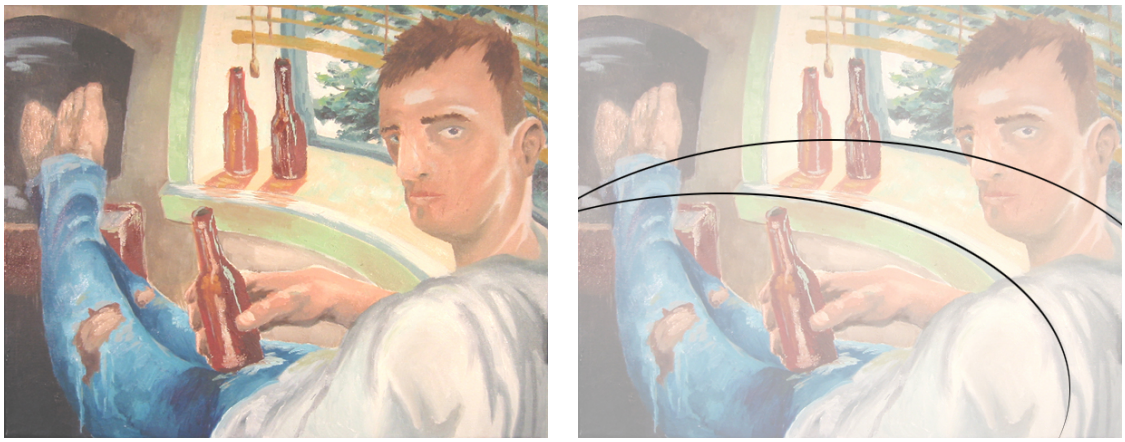

Fig. 3. Flowing perspective.

A second type of perspective variation I define as "pattern-less perspective". Figure 4 shows how traditional art may have objects that appear to be on the same

perspective plain, but when examined more closely, the perspective planes are unrelated. This almost looks as though it may be a parametric drawing, but again, the objects are not on the same plane.

Fig. 4. Pattern-less perspective.

3. Variations in color and lighting

Although there tends to be one defined light source in most traditional artwork, there is no guarantee that that will be the case. In many situations, each object in a painting can be treated as its own entity, and therefore the lighting of each object can vary significantly from object to object. The easiest way to determine local light sources is to examine the shadow directions. This allows for a precise angle at which to define the light source. If shadows are not depicted in the art, examining the highlights on an object can also help in defining the position of the lighting.

Further the color palette of an image is essentially unlimited. The level of saturation, the hues, and the light and dark values may all be determined by lighting, often based on some pattern or formula, but they are as likely to be more or less random in configuration.

4. Variations in style and mark-making

Variations in style occur mainly when the materials, or media used in the artwork change. If one section of a piece is done with pen and ink, and another adjacent section is done in watercolor, the mark-making will shift in character. An object in the pen and ink section may require a different surface material than an object in the watercolor section.

CHAPTER II

RELATED WORK

There has always been a goal in computer graphics to create believable, or convincing images. Although this goal has always existed, what is accepted as "believable" has become much broader in recent years. In the earlier years of computer graphics, "believable" meant essentially "lifelike" called photo-realistic. While this continues to be a challenge in computer graphics research and practice, other ideas of what is accepted as believable have been developed. One example of this development is the goal of creating images that are believable within the scope of being created with traditional artistic techniques. This goal is often described as non-photorealistic rendering [1]. However, the rendering process is just one aspect of the production pipeline that has been researched. Other work has been done to help directors create, among other things, environments, camera movements, or lighting styles that are at once stylized and believable.

A. Non-photorealistic rendering

Non-photorealistic rendering is the term used for any type of rendering with the goal of creating artistically stylized images as opposed to images that appear to be photographic. Often the goal of non-photorealistic rendering is to mimic some sort of traditional style. Examples of this could include trying to match the color bleeding of a watercolor painting or the texture of an oil painting. Non-Photorealistic Rendering is a book by Bruce and Amy Gooch which brings together and catagorizes much of the published research on the subject [2].

1. Emulating styles

Much of the research done in the field of non-photorealistic rendering has included emulating different types of mark making and style. "Painterly Rendering for Animation" studied ways to render images such that their execution mimics brush strokes. The main problems solved in this particular paper involved correcting specific problems with the way the brush strokes would stick to the viewport as opposed to the rendered surface as well as fixing frame to frame coherence in an animation [3]. Aaron Hertzmann worked to develop a method for painting an image with a series of spline brush strokes. The strokes corresponded to a source image, and would build up from larger strokes to smaller strokes in a series of layers. Hertzmann was beginning to explore the expressive quality of complex brush strokes [4]. John Haddon's "Sketchy Rendering" describes the creation of custom rendering techniques used in the animated short, "A Flatpack Project". The challenges included reproducing the appearance of line drawings in both pencil and ink, along with other effects such as the bleeding of ink in water and the application of pastel to paper [5].

B. Computer graphics and traditional artwork

At the Texas A&M Viz Lab there has been a number of examples of interest in using traditional art as an influence for creating digital images. One main influence for my research was the work done by Michael Stanley in his thesis, "Digital Compositing with Traditional Artwork". In this thesis, Stanley defines some basic guidelines for compositing CG elements with traditional artwork. His main concentration involves matching the global perspective and style, as well as accounting for some general errors which are inherent in traditional art [6]. Another thesis which focuses on traditional art and computer generated images as a response to the art is Kevin

Thomason's "Capriccio after Davison: Translating Two-Dimensional Still Imagery into an Artistic, Dynamic Three-Dimensional Space". In this thesis, Thomason uses work done by Richard Davison Jr. as an influence for creating a three-dimensional space [7].

C. Other areas of related research

In Daniel Wood's 1997 Siggraph paper, "Multiperspective Panoramas for Cel Animation", Wood examines a panoramic image used in the opening sequence of Disney's "Pinocchio". The panorama is a single background image which is used to incorporate multiple views of a 3D environment as seen along a given camera path. When viewed through a small moving window, the panorama produces the illusion of 3D motion [8]. An important aspect of this research as it relates to my application is the way in which the local information is viewed separately from the global, and how the perspective in the global image is never really "correct". The 2004 paper, "Non-photorealistic Camera: Depth Edge Detection and Stylized Rendering using Multi-Flash Imaging" presented a non-photorealistic rendering approach to capturing and conveying shape features of real-world scenes [9]. This basically stylized a scene by simplifying its elements down to edges and colors. "Artistic Multiprojection Rendering" uses the idea of multiple projections in traditional art and applies it to enhancing computer-generated images and animation. This paper uses traditional pieces such as Giorgio de Chrico's "Mystery and Melancholy of a Street" and Cezanne's "Still Life with Fruit Basket" as a guide for using multiple projections which are used to create visual emphasis and interest and then applying those projections to computer-graphics [10].

CHAPTER III

PROCEDURE

Compositing computer generated objects and materials into traditional artwork poses a number of challenges. Here I define a procedure for handling these challenges and producing composites that are both visually believable and aesthetically appealing.

A. Examining the art

It is not always the case that the CG artist will be compositing CG elements into his/her own work. The CG artist may not have the opportunity to interview the creator of the work being composited with CG elements. This is why I have defined the initial step in my procedure to be examining the art itself. It is important to try and understand how a piece works visually before trying to composite CG elements into it. This includes, but is not limited to, understanding the composition, recognizing where variations in visual characteristics exist, and understanding the overall style of the work. Some questions that can be asked are:

- Is the piece realistic or abstracted (stylized)?
- What types of variations exist?
- How do the local components work in the global result?

One should not assume to understand another artists work completely, and sometimes assumptions must be made about what exactly something is, what it means, or how it works in the composition. Examining the art can make the compositing process more of a sculptural process where the CG element is carved into the work as opposed to interposed on top of it. Making all elements of the original image work

with the composited object will make that object seem as though intrinsic to the original image.

B. Separating the art into locally consistent sections

In a single piece of artwork, many unique sections may exist. When looked at as one image, these sections work together and are perceived as one final image. However, when compositing a CG element into the final image, it is important to design the composite around the local section in which it will exist. Sections are defined by variations in characteristics. The size of each section will depend on two factors: the artwork itself and the object being composited. The compositor must decide where to place the CG elements and what characteristics are important to that section of the artwork.

In some cases sections of traditional art are very easy to separate. The style, colors, or perspective may be completely different across the art and thus define each section. If this is the case, a composited object may have to exist in a number of different smaller sections. Conversely, some artwork has subtle differences from section to section. In this case, the size of the sections will depend more on the size of the object being composited.

In figure 5 there are three very different sections of a piece of art defined by their characteristics. The colors, perspective, and styles all vary in each section. For a piece like the one in figure 6, sections are not as clear and thus can be defined by the object that is being composited into the art.

Fig. 5. Three different sections.

C. Planning the composites and defining characteristics of each local section

The first step in planning the composite is defining which characteristics are the most important to the particular image and section being used. Some examples of major characteristics may include perspective, lighting, and style. Once these characteristics are established, more detailed minor ones can be defined. Some minor characteristics could be the texture, mark making, or the shadow color. Particular characteristics which emerge as minor or major will vary from image to image and section to section.

D. Adding the CG elements

The following steps are to all be considered before the final images are produced. The order in which these steps are performed is not always as important as the way in which they all work together. Each step should be applied to each CG element, and

Fig. 6. Less defined sections.

the characteristics should match those of the section they are being composited into.

1. Matching the defined local perspective

Matching an object to a local perspective can be done a number of ways. If the artwork being used has strait lines or edges that define the perspective, then they can be used to align a grid. If the perspective is more flowing or irregular, there may exist a need to draw a grid on top of the artwork before attempting to align it. Figure 7 shows one example of matching the local perspective.

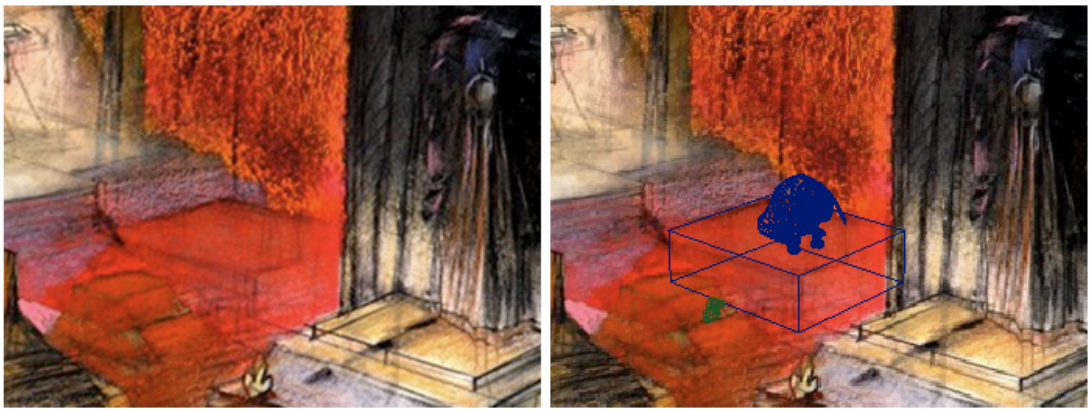

Fig. 7. An example of matching local perspective.

2. Modeling interactive objects

Any object in the artwork that the CG elements interact with must be modeled. Interactive objects include those which are seen as in front of CG elements, objects which the CG elements cast shadows onto such as ground planes, or objects that cast shadows onto the CG elements. These objects can be modeled in varying degrees of resolution depending on the application and context. Figure 8 shows two different modeled interactive objects: an object which the CG element will cast shadows onto,

and an object which will cast shadows onto the CG element.

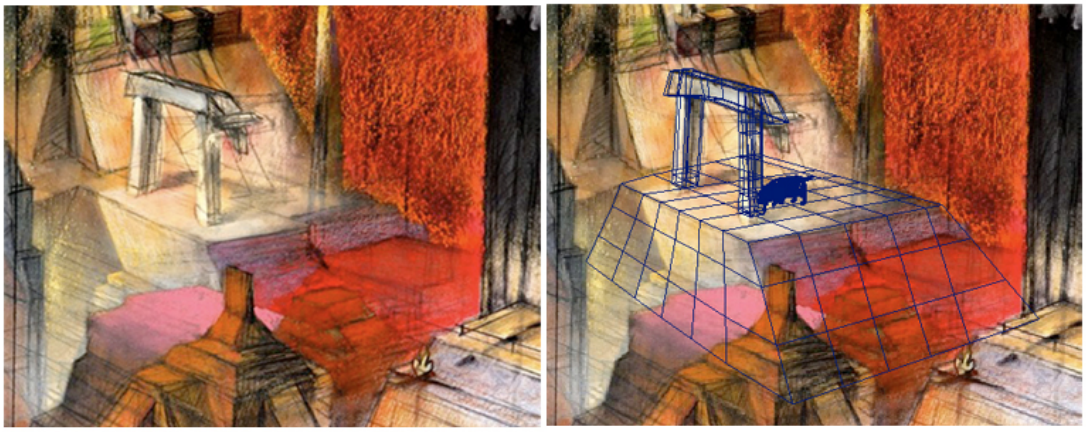

Fig. 8. This shows how different interacting objects can be modeled.

3. Creating the surface materials

In every CG project, there comes a time to decide what type of surface materials will be used. A good, flexible procedural shader might allow for a CG element to move around a work of traditional art and conform to the local characteristics of that art as it moves around it. This would be the ideal shader to use. However, developing a shader capable of handling every type of mark-making and style possible in a work of traditional art could be a daunting task. Therefore, one alternative would be to use texture maps.

The main point in creating surface materials is to insure that the material has the capacity to hold lighting well and also that it makes sense for the element it is being applied to. Another often-used addition to a surface material is the use of displacement in order to eliminate sharp or straight edges. One curious aspect of CG is that it tends to "look CG", especially when it is adjacent to something natural. Using displacement can give an otherwise geometric object a much more natural feel.

4. Developing the light source

The light and shadow directions must make sense with the local information. Traditionally there will be a key light and a series of bounce and rim lights, however this is not a rigid concept. Getting the direction of the light correct is the main challenge here, but matching the qualities of the light (such as color, soft or hard, or angle of throw) is equally important.

5. Creating shadows

Finding the correct shadow angles is primary, and it is also crucial to make sure the shadows follow the contours of the environment they are cast upon. In most cases it is best to create shadow masks that can be used to define shadow regions, which can then be used in the final layering and compositing steps. This will allow more control over the final look of the actual body of the shadow. Ambient occlusion can be used to create contact shadows, but it should only be used in situations that call for it.

6. Integrating element(s) with surrounding artwork

An important consideration in the process of composting CG elements into traditional artwork is to integrate all aspects of the elements into the artwork. For instance, a standard shadow does not fit in the art like one which integrates local information in its creation. This can be seen in figure 9. Using existing information such as brush strokes or pen lines in the creation of the CG elements textures or shadows can help a great deal in making that element feel like it is part of the original work.

Fig. 9. Comparison of no shadow, initial shadow, and integrated shadow.

E. Unifying local and global information

Because the composited objects have been matched to local information, they should in concept fit globally. However, some mistakes could be made if in the process the compositor does not consider the overall image. For example, if a composited object had a portion that was red. Although this may seem acceptable when looking at it in a small section of a piece of art, if that art had no other occurrences of red in the entire piece, this area would stand out and look incorrect.

CHAPTER IV

IMPLEMENTATION AND RESULTS

A. Implementation and software

To implement my procedure, I use three pieces by Professor Richard Davison Jr. and one painting that I have created myself. I follow the steps outlined in the procedure to create images that combine the traditional pieces with CG elements, and I also create a short animation using the results from one of these images. The animation shows how the procedure works for any number of frames, and not just one still image. I import the traditional work into Maya, and use that program to create the 3D elements, match the perspectives, and set up the lighting. I create the texture maps for the surface materials of the objects using Adobe Photoshop, and import those into Maya as well. The images are rendered using Mental Ray, and the final compositions are assembled and rendered in Adobe After Effects.

B. Case studies

The four images that I use to implement my procedure will be referred to as *Afternoon*, D15, D13, and D02. Each image requires the same steps to composite CG elements into it, however each image also contains specific areas of focus. After examining each image, I was able to determine what particular aspects of each would need the most concentration and planning. Figure 10 shows the four images used as case studies.

C. Planning the composites and defining sections

After examining the art, I was able to begin planning where I wanted to place each CG element. After this I was able to further define the sections of each image in

Fig. 10. Four images used: *Afternoon*(top left), D15(top right), D13(bottom left), and D02(bottom right).

order to determine what characteristics each CG element would need to fit into that section. Figure 11 shows the four case studies divided into sections.

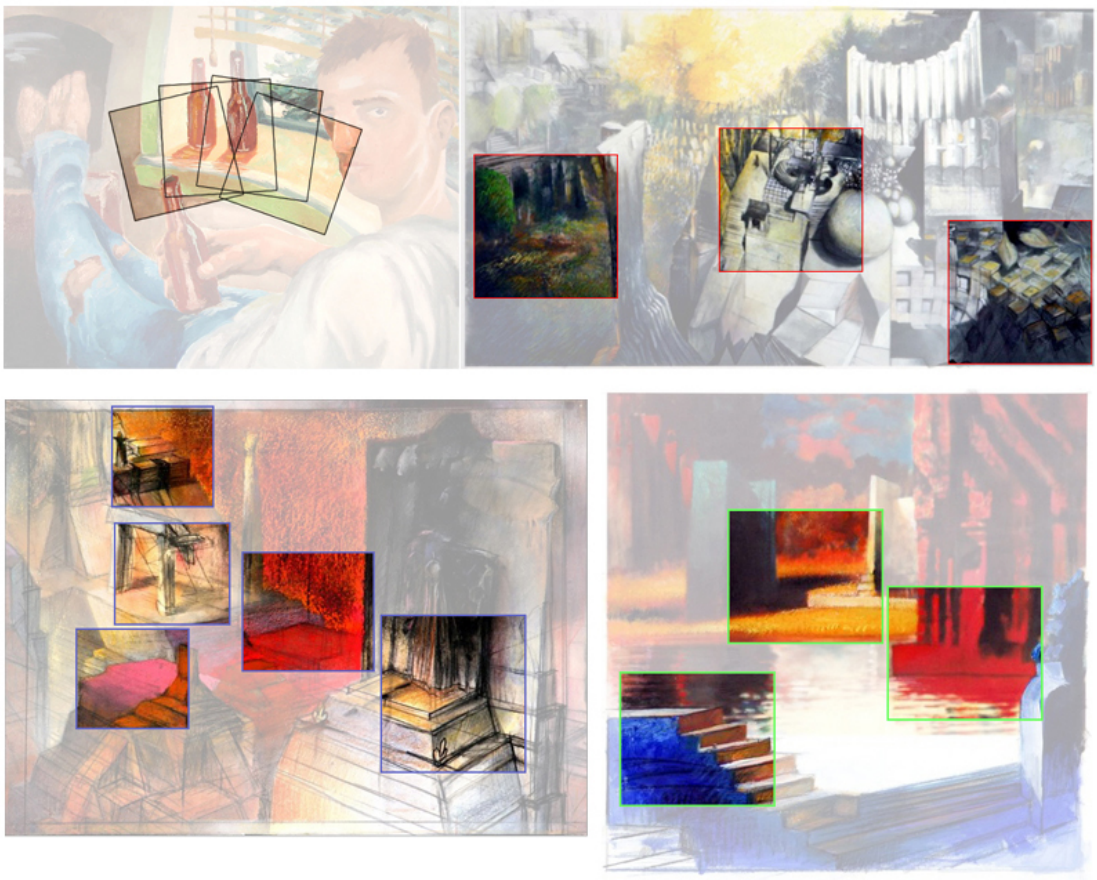

Fig. 11. Determining locations for CG elements and defining the sections.

D. Adding CG elements to D02

D02 (seen in its original form and divided into sections in figure 12) offered an opportunity to fully examine what the lighting in a traditional painting might entail. I decided to add three boxes to the image in three very different sections of the art. Because the only information about what kind of world this might be is provided by the red sky with blue clouds, I made a few assumptions.

My first assumption was that any object composited into this art must match the colors of that section exactly. For instance, the red and black area on the right may have been meant to be a large red object, but I assume that its color is a result of it being surrounded by red light. The light is what gives it the color, and therefore any object adjacent to it will also appear red and black. I make similar assumptions for the blue, orange, and white area on the left, but for the section in the middle I assume there is a warm, natural sunlight.

Fig. 12. The original image on the left and the individual sections I chose on the right.

1. Matching the perspective

In D02, I was able to use existing right angles and ground planes to establish the perspectives. The general layout can be seen in figure 13. Once I had the basic positioning of each of the boxes I was able to adjust them slightly in order to better match the specific local perspectives. Although the boxes appear to be on the same plane, figure 14 shows that they are planes specific to each area.

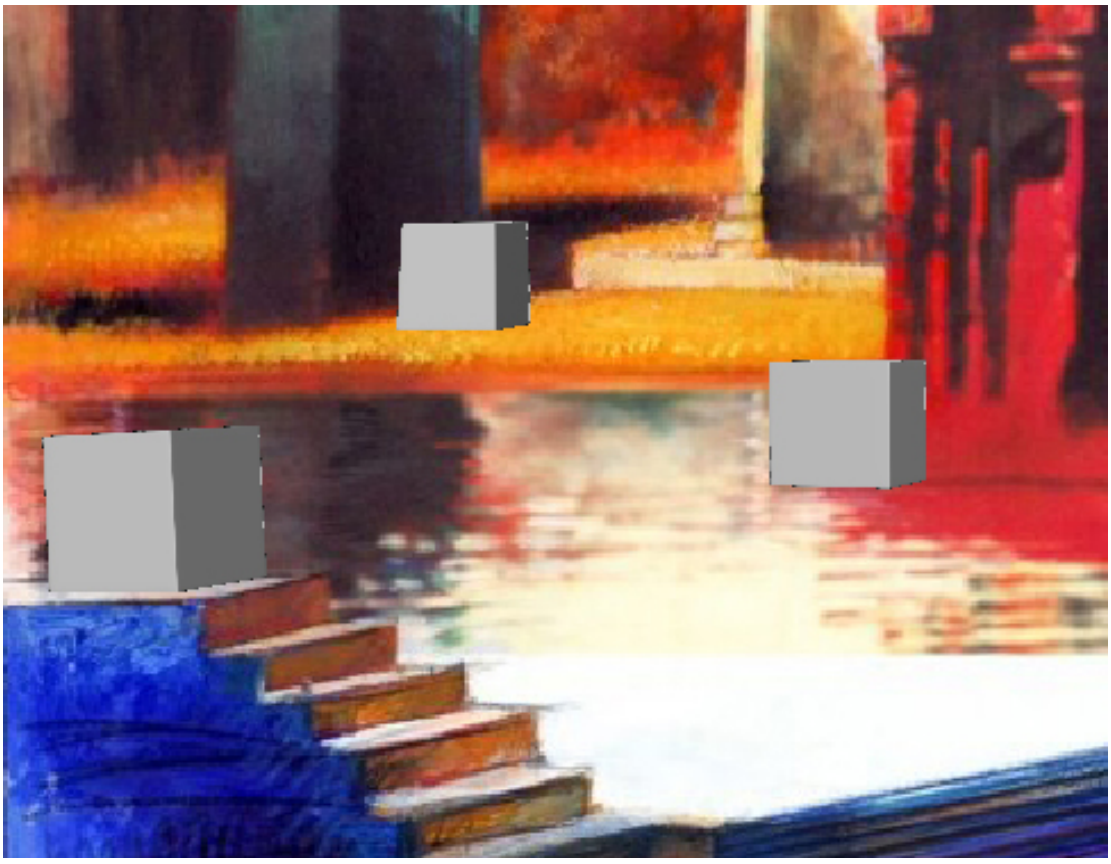

Fig. 13. This image shows the general layout for matching the perspective in D02.

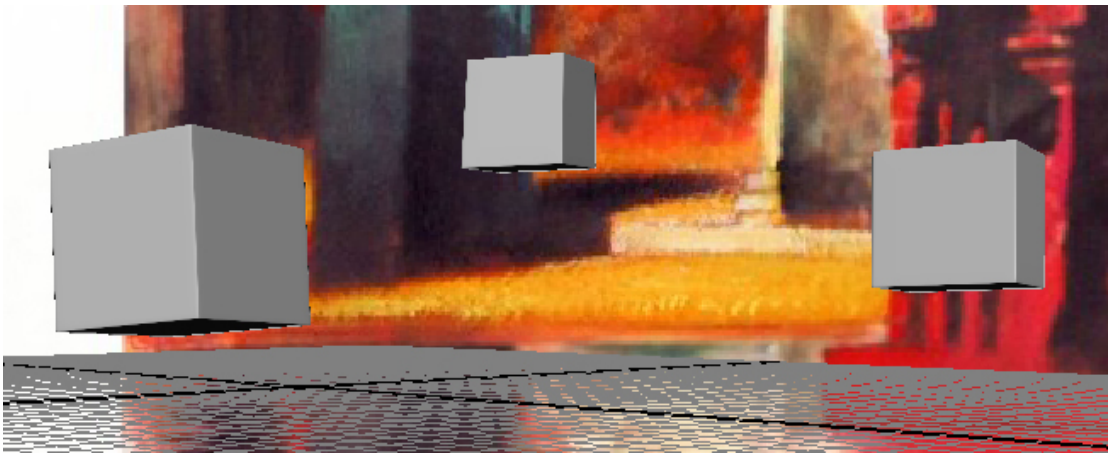

Fig. 14. Here you can see that the boxes are not on identical planes. Adjustments have been made to each individual box.

2. Modeling interactive objects

The interactive objects in D02 were limited to ground planes and planes for receiving shadows. One of the important ground planes was that of the water for creating the reflection of the red box. These planes can be seen in figure 15.

3. Creating surface materials

Because of the assumptions I made about the lighting in this image, the color of the surface material was obsolete. I decided to use a simple white Lambert material for the boxes. Although the color was simple, this image was one which required displacement. The image contains a significant number of geometric shapes, but the borders and edges of these shapes are all rough and natural. This comes as a result of painting and drawing with charcoal, and it means that if there were a hard-lined CG elements sitting amongst them those elements incongruous with the whole. Figure 16 shows the boxes with the white surface material and the setup for the shader in Maya.

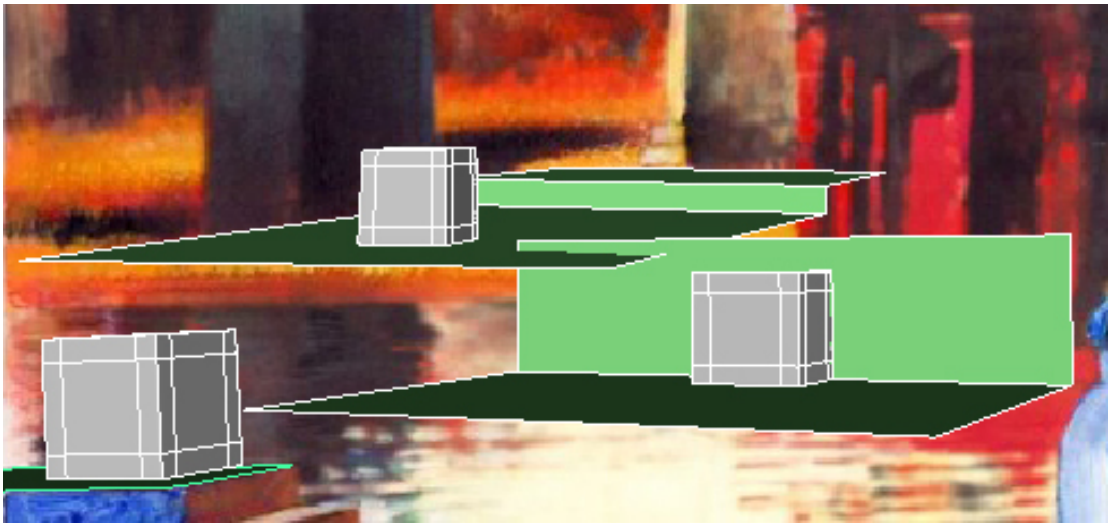

Fig. 15. Ground surfaces for casting shadows were the main interactive objects which needed to be modeled. I also modeled a plane to create the reflection for the red box on the right.

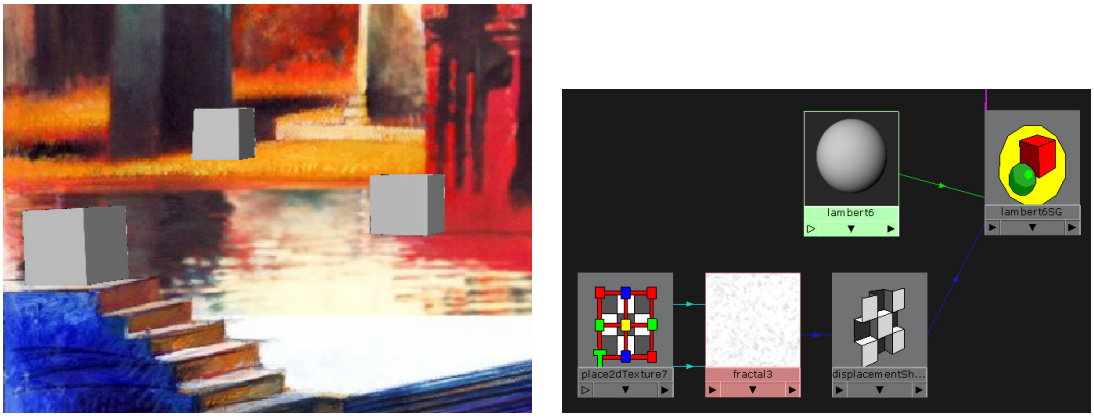

Fig. 16. The left image shows the boxes with the simple white Lambert shader, and the right image shows the setup for the displacement.

4. Developing the light source

For this image I decided to concentrate primarily on the lighting. I wanted to create a lighting setup that would work for any element composited into a specific section such that each light has a strong amount of color in it. I also wanted the lighting to create some variation on the surfaces of elements they illuminate, and for that reason I used a greater number of lights which overlap in some areas. Figure 17 shows the lighting setup, and figure 18 shows the boxes with the lighting applied.

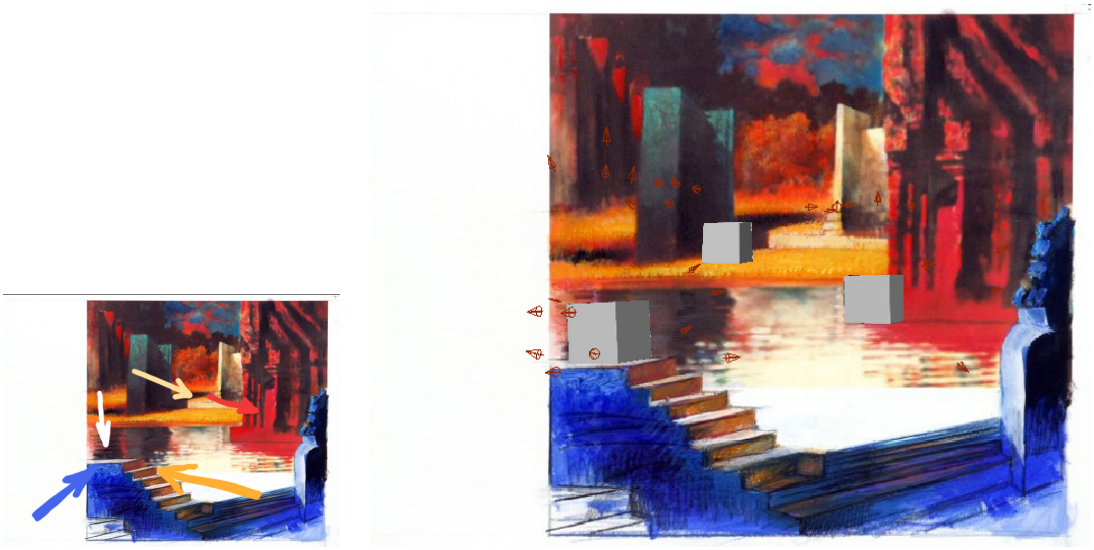

Fig. 17. Planning for the lighting setup can be seen on the left, and the lighting setup, produced in Maya, can be seen on the right.

5. Creating shadows

The shadow angles and colors were determined by examining adjacent shadows. The middle box shadow is modeled after the shadow cast by the large green object, and the red box shadow is modeled after the shadows cast on the large red object itself. The reflection in the water is constructed in a similar manner. This image did not

Fig. 18. Here are the boxes with lighting applied.

require heavy contact shadows, and occlusion was not used. Instead, the contact shadows are created using a stroke layer style in the compositing process. Figure 19 shows the shadow construction for this image.

Fig. 19. The left image shows the shadow maps and the right image shows the painted surface areas.

6. Integrating with the artwork

Integration for this image was done primarily by using lighting to match surface colors. More detailed integration includes a stroke layer style applied to the left box to match the dark outlined style of the surrounding objects, the water reflection for the right box, and the grass in front of the middle box. Figure 20 shows this.

7. Final image

After all of the steps had been completed, I was able to create a flexible and believable final image (seen in figure 21).

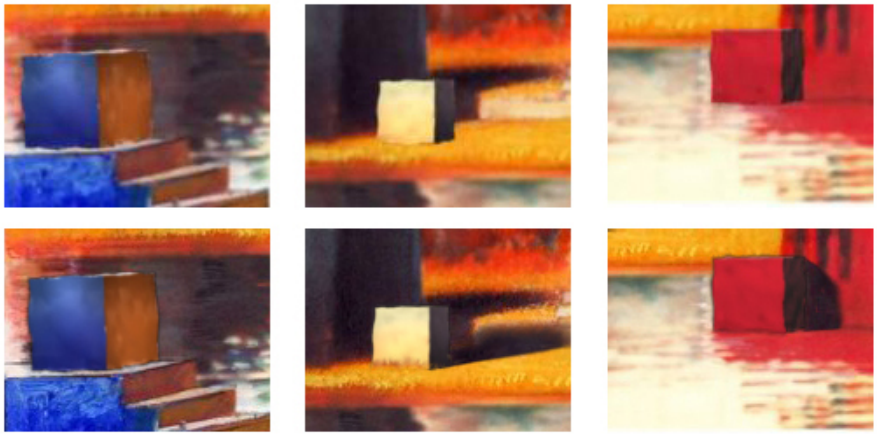

Fig. 20. Integration with the artwork. The top images show the boxes without integration, and the bottom images show them with integration.

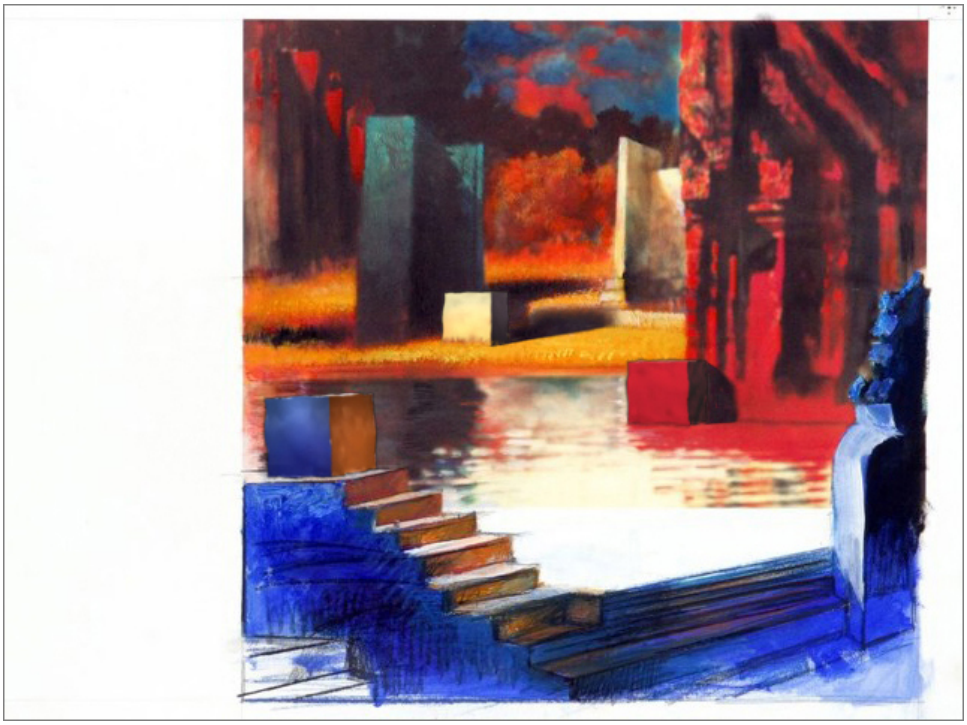

Fig. 21. The final image of D02.

E. Adding CG elements to D15

In D15 my concentration was compositing CG elements into an image with an extremely high level of variation. As seen in figure 22, every characteristic in D15 varied across the image. The perspective starts from an orthogonal type view on the right, and works its way to deep canyon perspective. On the left side of the image, there is a very traditional impressionist style to the mark making, while in the middle the style suggests something closer to pen and ink. I chose to use a combination of strategies in order to create a believable final image.

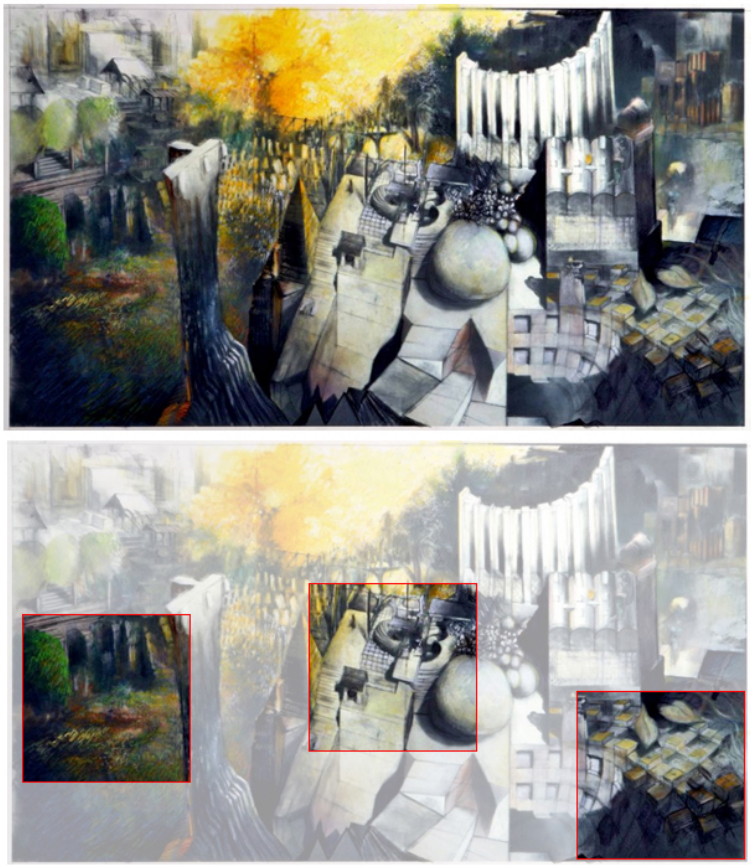

Fig. 22. The original image on top and the individual sections on bottom.

1. Matching the perspective

As stated before, D15 had a wide range of perspectives to handle. The variety in perspective is so confusing at times, I was mistaken in my interpretation of it. The right side of the painting is an orthogonal view of some objects, but upon my initial inspection of it I interpreted it as some form of overhead view. After discussing my work with professor Davison, he pointed out my mistake. Although it is technically an error, I decided to leave it as it is to show how incorrect interpretation of a painting will not necessarily lead to bad results, and interpreting the work is necessary when the artist is not available to ask questions. The chair in that section still seems to fit correctly. Figure 23 shows the setup.

Fig. 23. Matching the perspective for D15.

2. Modeling interactive objects

This image required modeling objects such that shadows could be cast onto them. The chair on the right required a ground plane only, the middle chair required some walls and ground planes, and the chair on the left required a ground plane and a "bush" for shadows. I also modeled a small shape to mask out the legs of the chair and make it appear as if they were contacting the grass. Figure 24 shows this setup.

Fig. 24. For this I needed to model primarily ground planes, but I also modeled other surfaces.

3. Surface materials

Unlike the surface materials in D02, I painted different textures for each of the three chairs here. The main reason for this was the pen and ink section in the middle which required a black and white texture. The left-hand chair required the greatest amount of painting to make it assimilate with the impressionist style adjacent to it. Figure 25

shows the three painted textures. There is also slight displacement on the left and right chairs to account for the natural brush strokes of the style they exist in and eliminate the strait edges.

Fig. 25. As opposed to the boxes in D02, each chair had it's own texture specifically designed for the section it was in.

4. Developing the light source

Figure 26 shows the result of the lighting applied to the chairs. Although most of the surface color is in the texture, some is provided by the lighting. This is evident in the middle chair where some yellow light helps accent the chair and further relate it to the original image. The other main goal with the lighting in this image was to define the forms in manners similar to the forms adjacent to them in the original image.

Fig. 26. The purpose of the lighting in D15 was to define the forms of the objects in a similar manner to the adjacent objects.

5. Creating shadows

The shadow construction for D15 was relatively basic. I used surrounding information to determine the shadow characteristics, created the shadows as standard masks, and then painted shadow areas again using local information. The setup of the interactive objects made this step easy. Figure 27 shows the shadow masks and painted shadow areas.

Fig. 27. The shadows were created by using the local shadow characteristics.

6. Integrating with the artwork

Integration for this image was done primarily in the shadow painting step. Figure 28 shows two of the areas with no shadow, a simple black shadow, and an integrated shadow.

Fig. 28. Integration for D15 was focused on in the shadow areas. From left to right shows the progression from no shadow, a black shadow, and an integrated shadow.

7. Final image

Even with a technical mistake in the perspective of one of the chairs, the resulting image is believable. Figure 29 shows it.

Fig. 29. The final results for D15.

F. Adding CG elements to *Afternoon*

This image is a special case for two reasons. The first is that it is my own image, and therefore I know everything I was thinking when it was originally created, and the second is that the style is completely different from professor Davison's work. One of the main differences with my image is that the sections are not as well defined. The main characteristic that stands out is the flowing perspective of the window sill. This is the result of using a curved mirror when I painted this image, and it presents a new challenge for compositing CG elements. Figure 30 shows the original image as well as the image diveded into sections.

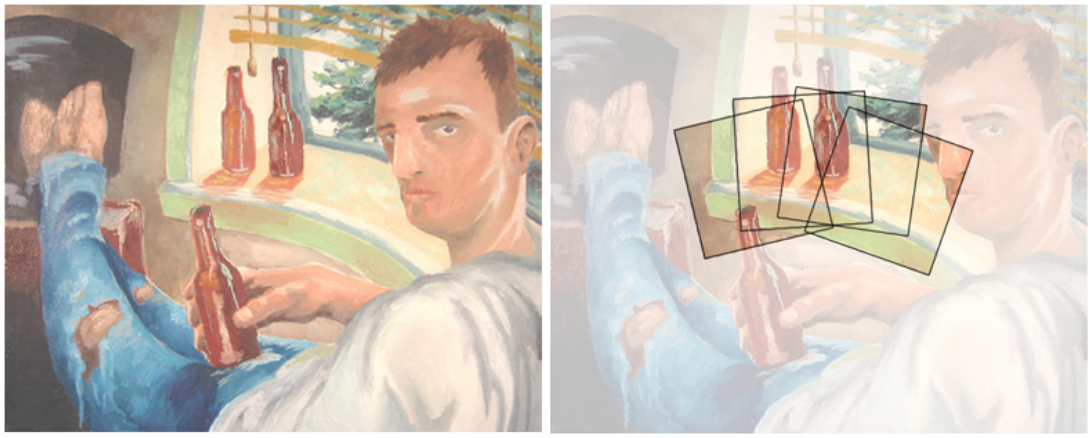

Fig. 30. The original painting on the left, and the sections on the right.

1. Matching a flowing perspective

As stated, the main characteristic that stands out in this image is the flowing perspective. In order to take advantage of this unique characteristic, I chose to composite three cans along the curved window sill. My first step was to average the perspectives and align my grid with this average. Once I placed the cans along the grid, I went

back and adjusted each can to fit the local perspective. In figure 31 the the initial layout for the perspective is shown as well as the adjustments made to match the cans to their specific local perspective.

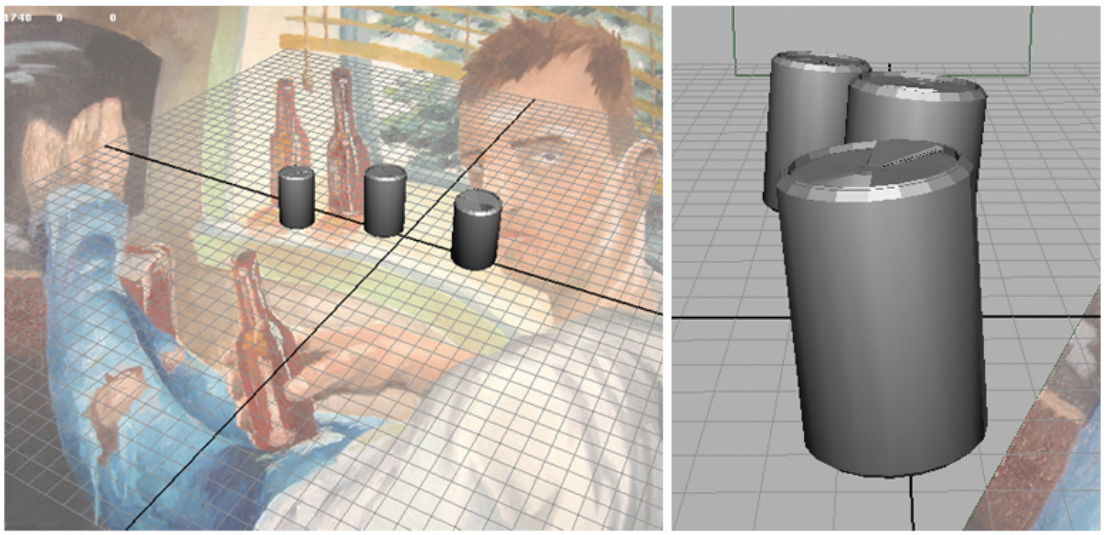

Fig. 31. The left image shows the setup of the grid, and the right image shows the adjustments made to each can to match the specific local perspective.

2. Modeling interactive objects

The primary object which required modeling was the curved window sill. I needed to include enough geometry to hold the curve of the shadows cast by the cans, as well as account for the curvature from front to back of the sill. The other object that required modeling was the face. This model only needed to be a low poly approximation in order to create a mask that could be used to block out the can on the far right. The resulting models can be seen in figure 32.

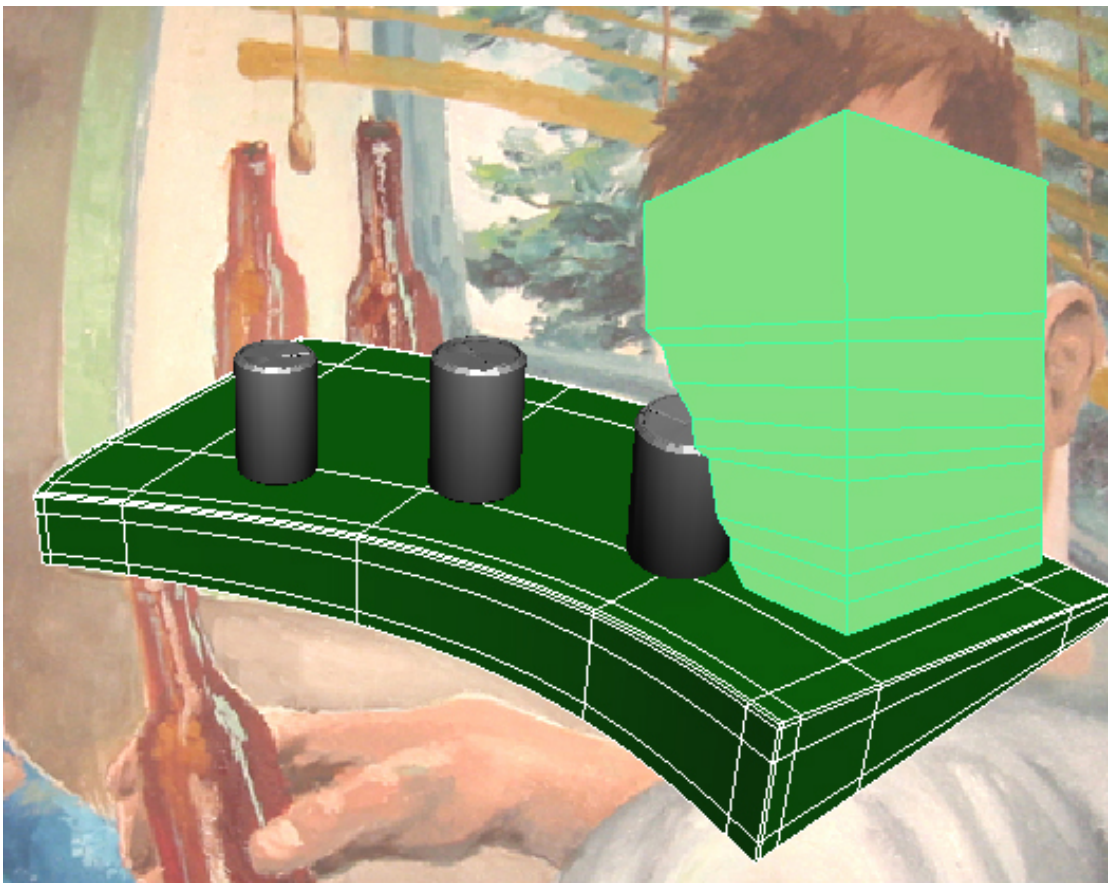

Fig. 32. The window sill was the most important interactive object. I had to model it with enough geometry to hold the curve of the shadows. I also modeled a low poly approximation of my face to use as a mask.

3. Creating surface materials

To create the material for the cans, I used the blues in the pants from the original image. I wanted the cans to have the same painted feeling as the rest of the image, so I also needed to use displacement. This made a great difference in the appearance as there are no straight lines in the original image, and without the displacement, the edges and borders of the cans were too sharp in appearance. The painted texture and the setup for the displacement can be seen in figure 33.

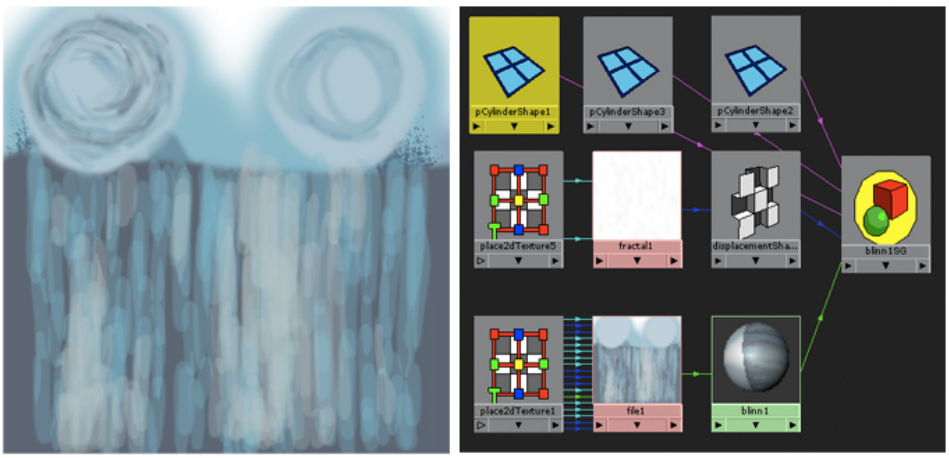

Fig. 33. On the left is the painted texture, and on the right is the setup for the displacement.

4. Developing the light source

In *Afternoon*, the main key light is coming from the window. Since the window is curved, the light also curves. I had to add an array of backlights and rim lights to account for this, and also several fill lights since the entire painting is relatively bright. The backlights are the source of the shadows, and the lighting setup can be seen in figure 34.

Fig. 34. The left image shows the planning for the lighting, and the right image shows the setup in Maya.

5. Creating shadows

As stated, the shadows are being cast from the backlights, since that is the location of the primary light source is. I used the shadows of the existing bottles to establish this, and then I once again used the blues from the original image to paint the shadow color. I used some occlusion for grounding the objects, although it is not very heavy due to the fact that there are not strong contact shadows anywhere else in the painting. Figure 35 shows the shadow masks, the occlusion used for grounding, and the painted shadow areas.

6. Integration with the artwork

The main source of integration here was the use of the existing blues from the original image in the creation of the surface material and shadow colors. Because this was my original work, the style and mark making were naturally similar. Figure 36 depicts how the existing blues were used.

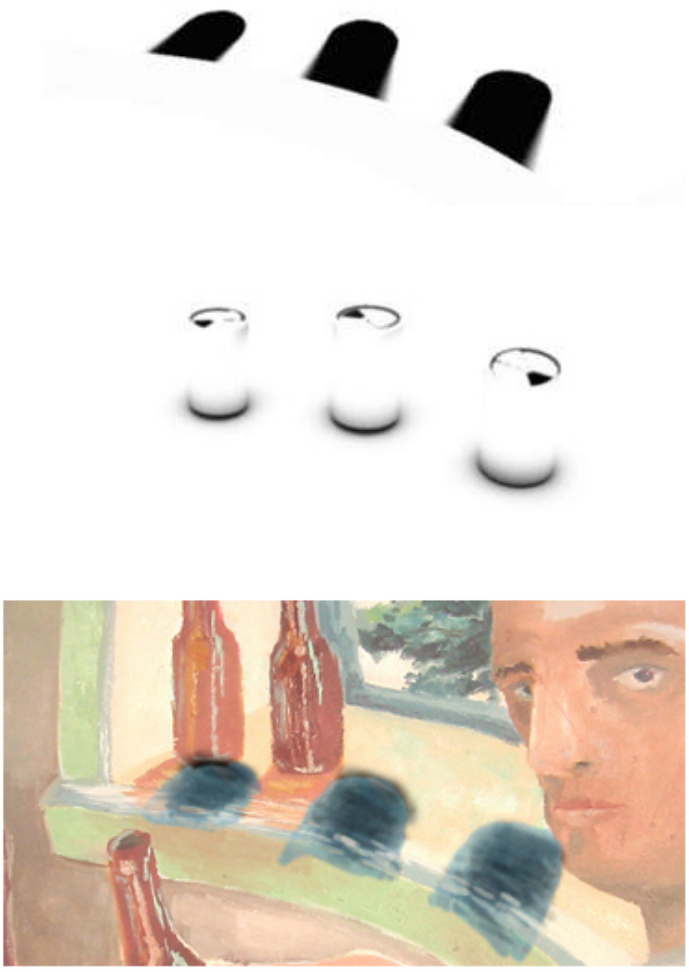

Fig. 35. Top view shows the basic shadow masks, the center view shows the occlusion, and the bottom shows the painted texture area.

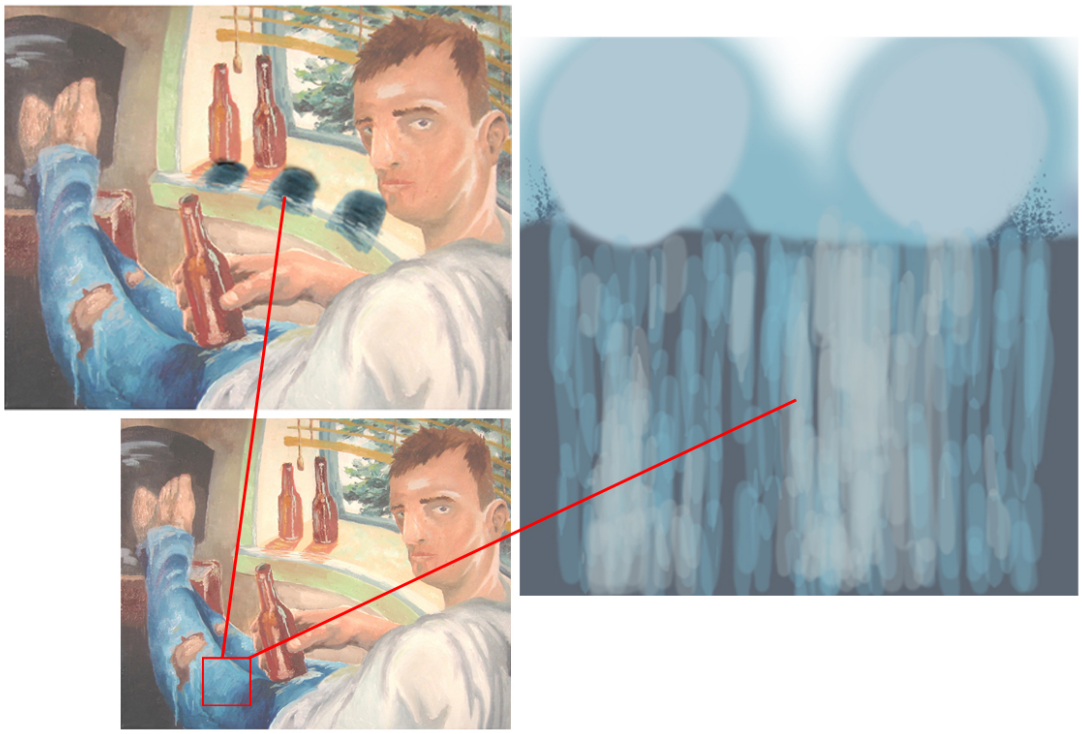

Fig. 36. Existing blues from the original image were used to create the surface material for the cans as well as for the shadow color.

7. Final image

The final image in figure 37 shows the cans situated on the window sill among the existing bottles.

Fig. 37. Final composited image of *Afternoon*.

G. Adding CG elements to D13

The primary challenge with this image was the variety in the sections. There is a great deal of variation in color, style, mark making, and perspective. Figure 38 shows the original image on the left and the image divided into sections on the right.

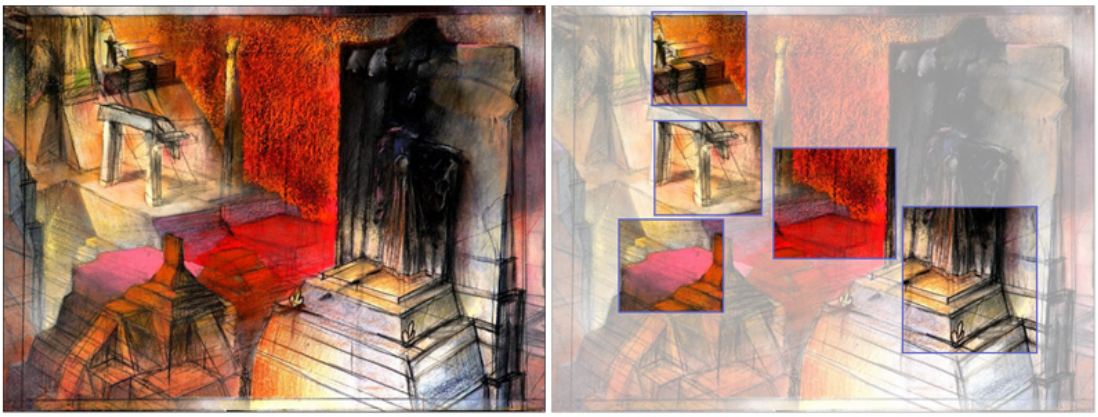

Fig. 38. Original image on the left and sections on the right.

1. Matching the perspective

This image contains a number of right angle geometries which made it easy to align with grids and Maya geometry. I simply used the existing angles to determine each local perspective. Figure 39 gives one example of how existing geometry was used to align CG geometry.

2. Modeling interactive objects

Each section in D13 required some modeling to be done. Although there were a lot of individual objects to model, each only required low poly approximations. Much of the modeling was simply ground planes to receive shadows, but there were also some

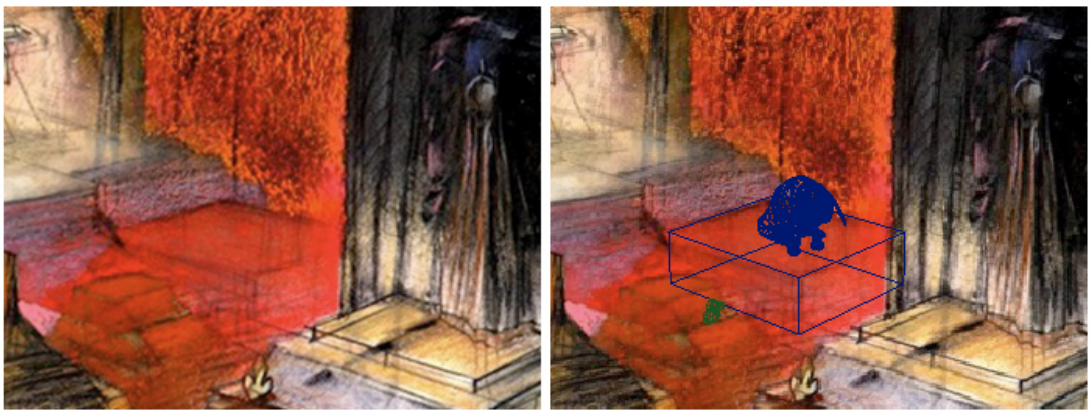

Fig. 39. An example of how the existing geometry was used to define the perspective of the composited elements.

objects which the dogs were either climbing on or walking behind. Modeling of the arch which the dog walks behind was necessary in order to create a mask, but also to create a cast shadow from the arch onto the dog. The main objects can be seen in figure 40.

3. Creating surface materials

For this image I decided to keep the material of the dog as it was originally modeled. In order to get the variation in color, I used colored lighting. Because the dog did not have any real straight lines or hard edges, displacement was unnecessary. One aspect that was added to the surface material in the compositing stage was a stroke layer style. This was controlled based on the characteristics of the section, and is most prevalent in the dog on the far right. The adjacent objects to this dog all have very dark outlines, so the stroke was used to mimic that. Figure 41 shows the setup for the layer style and its use.

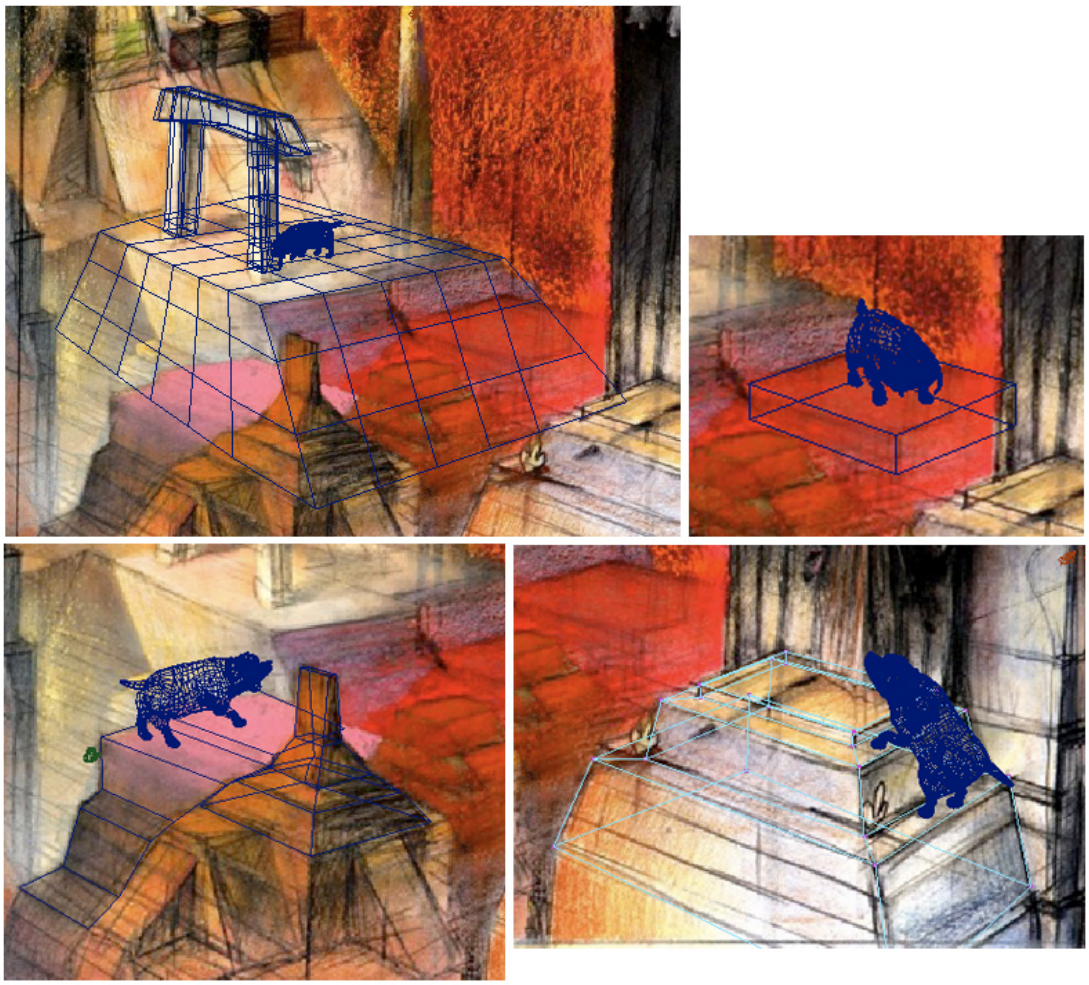

Fig. 40. This image shows a series of examples of modeled interactive objects. Most of the objects modeled were ground planes for shadows, but I also modeled the arch so a dog could walk behind it and the arch could cast a shadow on the dog.

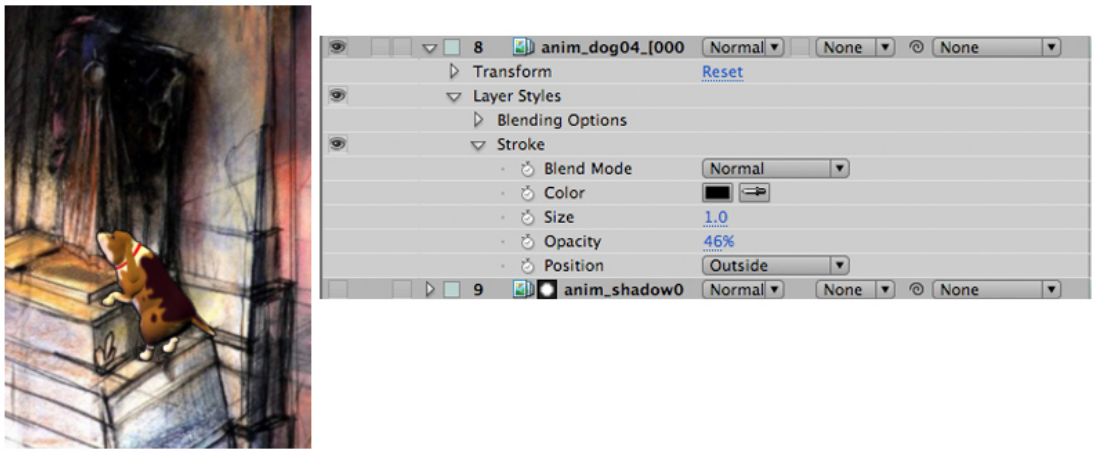

Fig. 41. This image shows the setup for a stroke layer style which is used to mimic the dark outlines in some areas of the image.

4. Developing the light source

The lighting in D13 was primarily used to create the variation in surface color of the dogs. If the dogs had retained the same white lighting originally applied, they would not look grounded in the art. The colored lighting acts as a way to implement the traditional artistic technique of color bleeding. Figure 42 shows a comparison between a dog with white light and one with colored light. The result is a much more coherent image.

5. Creating shadows

D13 has very little shadow information as compared to the other three images. One of the only areas that has an actual cast shadow is the section with the arch. Here the dog's shadow angle and color was based on this, but the rest of the sections left the shadows open for interpretation. I felt that although there were not a great number of cast shadows, the placement of the CG dogs created the need for some shadows. I

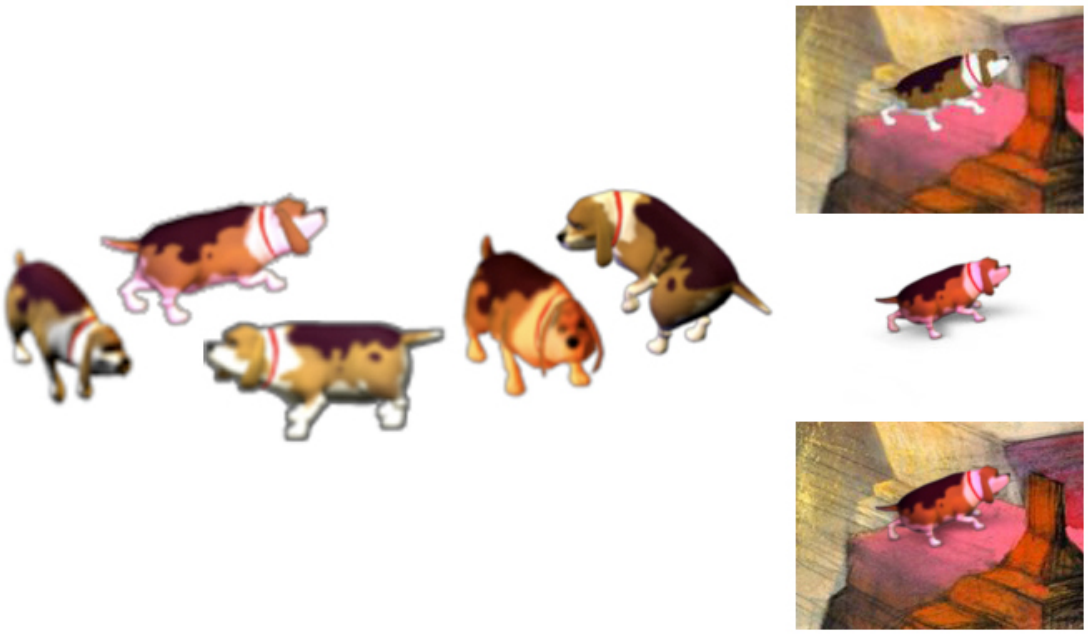

Fig. 42. The lighting in D13 was used to adjust the surface color of each dog to match their individual local sections. The left image shows the different surface colors of the dogs, and the right three images compare a dog with white lighting to a dog with integrated lighting.

used the angle of the shadow cast by the arch to determine the angle of the rest of the shadows, but for the shadow color, I used local dark tones. For instance in the pink section, I used the darker purple color as the shadow color, and in the section on the right, I used the almost black tones in the object behind the dog for the shadow colors. Occlusion was also used for contact shadows, and the amount of occlusion was based on the characteristics of each section. Heavy occlusion on the right most dog and lighter occlusion on the pink dog. Figure 43 breaks down the steps used in creating the shadows of each section.

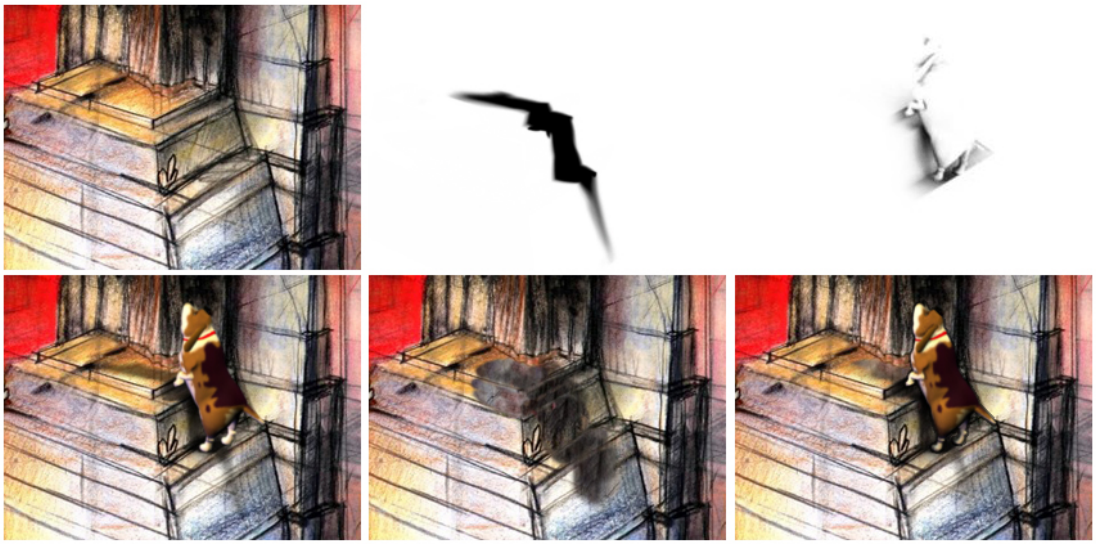

Fig. 43. This image shows the steps involved in creating the shadows for D13.

6. Integration with the artwork

In this situation, integration was done in every step. The modeled interactive objects both receive and cast shadows, the outline varies depending on what matches the section, lighting is used to adjust surface colors such that each dog fits the section it is located in, and shadow colors are painted using local colors and mark making.

This integration can be seen in the final image.

7. Final image

The resulting image is an M.C. Escher inspired scene. Instead of lizards or faceless men walking around, I have my obese beagle enjoying the wonderful environment created by Professor Davison. Figure 44 shows the result.

Fig. 44. The final composition of D13.

CHAPTER V

CONCLUSION

The process I developed for compositing CG elements into traditional artwork by using local information of that artwork is successful in handling the inconsistencies inherit in traditional artwork. By focusing on both local and global aspects of the art, the final composited images are visually believable. The global characteristics help the composites to stay consistent with the overall look of the work, and the local characteristics insure that the composited elements make sense with the visual information directly surrounding them. When the unique local characteristics such as perspective, lighting and color, or style are used to design the composites, visually seamless images can be achieved.

Another successful aspect of this research was the number of different approaches to matching the artwork. In the case of D02, lighting was the primary tool used to sculpt the look of the CG elements. In D15 the concentration was on the perspective. Although each different approach was unique, the resulting images accomplished the visual look desired.

In conclusion, this is a successful approach to compositing CG elements into traditional artwork.

CHAPTER VI

FUTURE WORK

Opportunities for future work could include developing shaders that are capable of spanning any number of sections of a piece of traditional art. In my research, I use texture maps for many of my CG element's surface materials. These are flexible and easy to control, but are not as capable of being animated as a procedural texture might be. Another possible area for future work would be developing ways to expand the entire 2D space of a painting into 3D space and then compositing CG elements into that. This would allow for the background to be animated as well as the integrated elements.

Another line of research could be compositing CG elements into more abstract work such as that of Jasper Johns or Pablo Picasso's cubist work. Most of what I have done has been with recognizable objects which would not be relevant in a cubist painting.

In my research, sections are defined and elements are then designed to fit into these sections. An expansion on this could be the interpolation between sections as well as developing how an element would look as it moves between sections of the artwork.

Automation of steps in my process is another area which could be explored. Most of the steps in my process are done by hand. This allows for a great deal of control for the look of the final images, however it can be slow at times. Automating some of the steps could speed up the process, but one would have to make sure that the artistic, hand crafted look is not lost.

One possible spot for automation is in the creation of the shadow areas. In my approach to the shadow area creation, I paint each area individually by hand. An

alternative to this could be using an image filter to read pixel colors of the original artwork and adjust them to darker shades. The challenge with this would be controlling the artistic look of the shadow areas and including some of the mark-making techniques used in darker areas of the artwork.

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